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ADVICE ON THE NORTHERN HUDSON BAY NARWHAL POPULATION BASED ON STOCK DYNAMIC MODELLING OF 1982-2008 AERIAL SURVEYS

*Narwhal (*Monodon monoceros*)*
by *R. Phillips*

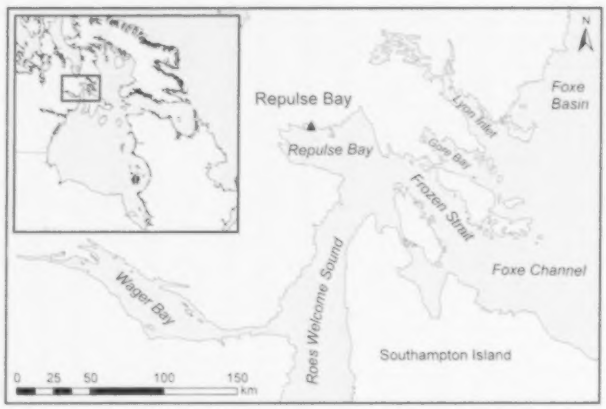

Figure 1. Areas where the Northern Hudson Bay narwhal population aggregates in summer in waters near the community of Repulse Bay, Nunavut (from Asselin et al. 2012).

Context

The hunt for the northern Hudson Bay (NHB) narwhals is a key Regional subsistence fishery. The most current Stock Status Report for this population dates to 1998 (DFO 1998). Since then, the population has been surveyed twice (in 2000 and 2008), and additional research has been conducted (contaminants, genetics, distribution and movements, hunting mortality, effect of killer whale predation). The results of the 2008 aerial surveys to estimate NHB narwhal abundance were reviewed at the 2009 National Marine Mammal Peer Review Committee (NMMPRC) annual meeting. The 2008 survey returned a low estimate of population size. The results may reflect a decline in abundance of this narwhal population. However there were problems with the survey. Equipment issues may have affected the survey estimate, in addition to environmental factors such as ice cover, survey altitude, killer whale predation, and possible movement of narwhals out of range of the survey. A Stock Dynamic Model for NHB Narwhals was developed to support the assessment of the status of the population. This included a review of the sustainability of hunting at the levels of recent years, and considered whether the low estimate from the 2008 survey might be explained by a serious decrease in population size.

SUMMARY

- The analysis suggests that the 2008 survey estimate was not reliable because the model could not be fitted to that survey without considerable adjustment.
- It reinforces the contention that the survey was severely affected by biases that produced an unrealistically low number for the NHB narwhal population. Modelling with increased

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killer whale predation starting in 2000 allowed a better fit to the 2008 survey estimate but only if predation removals were quite high.

- The modelling results are uncertain. Without more recent surveys to inform the model, estimating future sustainable catches for the Northern Hudson Bay narwhal population is difficult.
- It is recommended that a new survey be conducted as soon as possible to inform population trend and sustainable catches.

INTRODUCTION

The NHB narwhal population size was previously assessed from aerial photographic surveys of summer aggregations (Figure 1) in 1984 (Richard 1991), 2000 (Bourassa 2003), and 2008 (Richard 2010). The August 2008 survey was intended to provide information necessary for a full assessment of the population. Due to camera malfunction, sea ice conditions, and poor weather conditions, a partial estimate using the 21-22 August survey provided an estimate of population size that was only half of the 2000 estimate.

It has been reported that in the last three decades there is an increased number of observations of killer whales in the eastern Canadian Arctic in summer, and they are known to prey on narwhals. What effect this possibly increased predation level might be having on the dynamics and status of this quite small population of narwhals is not well known. However, it is thought possible that the low result of the 2008 survey could have been due, or partly due, to a real reduction of the population by sustained, and increased, predation.

A stock-dynamic model of the population of narwhals in northern Hudson Bay was built and run. Among the objectives were: to review the sustainability of hunting at the levels of recent years, which appear to have been on average significantly bigger than before about 1999; to evaluate the most recent survey, flown in 2008, which returned a low estimate of population size, but was plagued with problems of weather, sea-ice and equipment, and to consider whether the low estimate from that survey might be explained by a serious decrease in population size due in part or in whole to either recent increases in reported takes or by increased predation; and to estimate a sustainable take from the population.

ANALYSIS

A simple stock-dynamic model using Bayesian methods was developed to assess the population size indices updated with the catch history to inform management of this population (Kingsley et al. 2012). The model was run with the 2008 survey, without it and also by adding killer whale predation to understand their influence on the time series of population size estimates. A fourth version of the model was run in which there was no process error and the stock dynamics were deterministic (i.e., behave predictably).

The model could not fit with the 2008 survey included, without adding a lot of process error to allow it to adjust to this outlying value. The model fitted much better without the 2008 survey and resulted in an estimated annual growth of 2.3% (Figure 2). After 1998, the fourfold increase in catches in the most recent 10 years lessened the rate of increase. Between the survey points, i.e., early 1980s and 2000, the uncertainty in numbers did not increase much, but uncertainty increased markedly with the most recent survey data point.

Predicted population trajectories were calculated for a range of reported landings. However, uncertainty about the present size and status of the population is much greater than the range of future trajectories over the catches modelled.

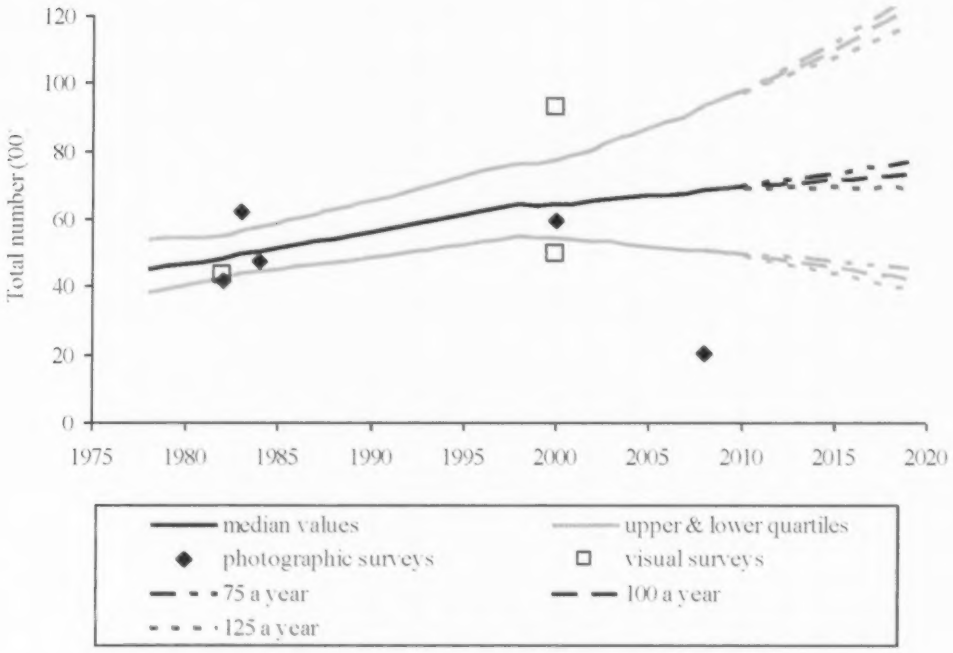

Figure 2. Modelled trajectory of estimated total number of narwhals in surveyed area, with 10-year projections for reported annual landings of 75, 100 and 125 narwhals. 2008 survey not fitted. Survey results standardised to median estimates of equivalent total number.

The low result of the 2008 survey could not be explained by higher catches since 1998. Having only a few survey estimates and lack of good information on hunting loss rates limited the ability of model results to estimate the present status of the population. The recent 2008 survey appeared incompatible with earlier survey estimates and reported catches. Model results could match the 2008 survey estimate by introducing predation since the preceding survey in 2000. However, the level of predation required to fit the survey results was high and would indicate that the population is unlikely to sustain even low catches.

Population projections were conducted using the parameters from the model fitted without the 2008 survey and not factoring in increased killer whale predation. Results indicate that the risk of causing a decline with the present level of landed catches (~90) or the sum of quotas (122) is greater than 35% (Table 1). The risk of causing a population decline larger than 10% in 10 years is greater than 20%.

Table 1. Estimated risks of decrease, and of decrease to less than 90% of 2009 numbers, under different levels of landed catch and assuming stochastic (i.e., chance or random) and deterministic stock dynamics.

	Probability (%) of population size in 2019 less than:			
	estimated 2009 population size		90% of estimated 2009 population size	
Landed catch	Model with no process error (deterministic)	Model with process error (stochastic)	Model with no process error (deterministic)	Model with process error (stochastic)
10	9.8	22.6	3.8	13.5
20	12.5	24.9	5.4	15.5
40	18.5	29.9	9.1	19.8
60	26.6	35.4	13.8	24.8
80	34.4	40.7	19.8	29.8
100	42.0	45.2	26.4	34.5
120	49.3	49.8	33.0	39.3
140	55.6	54.3	40.0	44.2

Sources of Uncertainty

The deterministic model does not account for annual variation in parameters ("model process error"). Trial runs of the model with added process error did not result in significant changes of parameter estimates but projections of the model population into the future were less precise. The trial process error runs indicate that deterministic model projections overestimate to an unknown degree the precision of the estimated probabilities of future states of the NHB narwhal population. A reliable way of describing and estimating process error for this population would be needed to better estimate these probabilities.

Detailed information on actual hunt loss rates, and therefore more precise levels of catch mortality, as well as mortality from killer whale predation are also needed to more precisely estimate the present status and sustainable catch of this population.

CONCLUSIONS AND ADVICE

There are a number of reasons to believe the 2008 survey underestimated population size because of camera malfunction, sea ice conditions and poor weather conditions. Furthermore, the 2008 survey estimate is not consistent with the modelled population trend established by previous surveys. Modelling with increased killer whale predation starting in 2000 allowed a better fit to the 2008 survey estimate but only if predation removals were quite high. Given the uncertainty with the 2008 survey estimate it is recommended that a new survey be conducted as soon as possible to inform the population modelling and advice.

SOURCES OF INFORMATION

This Science Advisory Report is from the November 22-26, 2010 National Marine Mammal Peer Review Committee (NMMPRC) annual meeting. Additional publications from this process will be posted as they become available on the Fisheries and Oceans Canada Science Advisory Schedule at www.dfo-mpo.gc.ca/csas-sccs/index-eng.htm.

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